SCALE UP STUDY ON PRODUCTION OF BIODIESEL FROM JATROPHA CRUDE OIL

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ABSTRACT

Scale up is a very important activity in designing new industrial plants especially in specialty or fine chemicals production. The purposes of this study is to study on different between laboratory scale production and pilot plant production of biodiesel from Jatropha crude oil and to establish correlations between laboratory scale and pilot plant scale for construction of commercial plant. Transesterification process used KOH as a catalyst. The optimum quantity of methanol, catalyst KOH, reaction temperature and reaction time required for the transesterification of Jatropha oil were conducted by varying them. Then, the optimized conditions from laboratory scale were used in pilot plant scale. From this study, it was found that for laboratory scale and pilot plant scale, there are some differences in the value of the final yield. The difference of value of yield between the laboratory scale and pilot plant run was caused by several factors such as handling, operating conditions and others.

KAJIAN MENAIK SKALA MENGENAI PENGHASILAN BIODIESEL DARIPADA MINYAK JARAK

ABSTRAK

Menaik skala adalah satu aktiviti yang sangat penting dalam membina kilang industri baru terutama dalam pengeluaran bahan kimia khusus atau kecil. Tujuan kajian ini adalah untuk mengkaji perbezaan antara pengeluaran berskala makmal dan pengeluaran berskala pilot plant dalam pengeluaran biodiesel daripada minyak mentah Jatropha dan untuk mewujudkan hubungan antara skala makmal dan skala pilot plant bagi pembinaan kilang komersial. Proses pengtranesteran menggunakan KOH sebagai pemangkin. Kuantiti optimum untuk metanol, pemangkin KOH, suhu tindak balas dan masa tindak balas yang diperlukan untuk pengtranesteran minyak Jatropha telah dijalankan dengan mengubah kuantiti dan keaadaan parameter tersebut. Kemudian, keadaan yang telah dioptimumkan dari skala makmal telah digunakan dalam skala pilot plant. Daripada kajian ini, didapati bahawa untuk skala makmal dan skala loji perintis, terdapat beberapa perbezaan dalam nilai hasil akhir.Perbezaan nilai hasil antara skala makmal dan skala pilot plant adalah disebabkan oleh beberapa faktor seperti pengendalian, keadaan operasi dan lain-lain.

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LIST OF SYMBOLS

A	Area Total
Aei	Area Sample
L	Liter
V	Volume
g	Gram
kg	Kilogram
min	Minute
h	Hour
^{o}C	Degree Celsius

LIST OF ABBREVIATIONS

AR	Analytical Reagent
B100	Pure Biodiesel
CCRD	Central Composite Rotatable Design
FFA	Free Fatty Acid
GC	Gas Chromatography
H_2SO_4	Sulphuric Acid
KOH	Potassium Hydroxide
PAH	Polycyclic Aromatic Hydrocarbons
RSM	Response Surface Methodology

CHAPTER 1

INTRODUCTION

1.1 Research Background

During the research and development of a new chemical process, one of the problems is that merits close attention and often proves to be problematic is the scaling up the reactors. This is especially true of the biodiesel industry, which is characterized by unique gigantism that enables to produce and place products on market at relatively low prices, environmental friendly and without or less competition. The focus here is specifically on the chemical process found in the biodiesel industry. However, the problems are similar for material conversion processes, and the methodology presented can therefore apply equally well to the chemical and biodiesel industries.(Lu et al., 2009; Tiwari, et al., 2007)

Biodiesel is of recent growing interest recently and has been strongly recommended as a substitute for petroleum diesel. Biodiesel can be blended with petroleum diesel as it has similar characteristics with lower hazardous exhaust emissions .

Biodiesel is able biological sources such as vegetable oils and animal fats. The oils from vegetable crops and animal fats are extracted or processed to obtain the crude oil. It usually contains free fatty acids, phospholipids, sterols, water, odorants and other impurities. The free fatty acids and water contents have significant negative effects during the transesterification reaction of glycerides with alcohols using alkali or acid catalysts since they causes soap formation, consume catalysts and reduce its effectiveness and result in a lower conversion (Shuit, Lee, Kamaruddin, & Yusup, 2010).

The most important aspects of biodiesel production to ensure trouble free operation in diesel engines are: Complete transesterification reaction, removal of glycerin, removal of catalyst, removal of alcohol, and removal of free fatty acids. These parameters are all specified through the biodiesel standard, ASTM D 6751. This standard identifies the parameters the pure biodiesel (B100) must meet before being used as a pure fuel or being blended with petroleum based diesel fuel. Biodiesel, B100, specifications (ASTM D 6751–02 requirements).

Many researchers have been undertaken on vegetable oils as a source for diesel fuel which includes palm oil, soybean oil, sunflower oil, coconut oil, and so on. Jatropha curcas, a non-edible oil-bearing and drought-hardy shrub with ecological advantages, belonging to the Euphorbiaceae family, was found to be the most appropriate renewable alternative source of biodiesel.

A catalyst is usually used to improve and enhance the reaction rate so that the reaction can be completed in a shorter reaction time. Alkali-catalysed is preferred in industrial process. Transesterification of vegetable oils using methanol and alkali-catalysed has the advantages such as short reaction time and relatively low temperature can be used with only small amount of catalyst and with little darkening of colour of the oil.

According to , biodiesel production from high free fatty acid oil needs a two-step transesterification process which is acid esterification followed by alkali transesterification to get high biodiesel yield. The most important variables which influence the transesterification reaction are reaction temperature, ratio of alcohol to vegetable oil, catalyst mixing intensity and purity off reactant. Yield of biodiesel is affected by molar ratio, moisture and water content, reaction temperature, stirring specific gravity and so on.

1.2 Problem Statement

The starting point generally consists of laboratory results that concern a chemical transformation whose translation into economic gain appears viable. Tons or millions of tons of raw materials industrially are treated in process production development whereas only grams or kilograms of these raw materials are used in the laboratory. This is the precise function of change of scale or scale up. To achieve the neraest conversions, yields and selectivity in production of biodiesel from Jatropha oil is the problem to reproduce the laboratory results on a large scale. In some cases, it possibly improves the results. To go directly from the laboratory to the industrial scale is rarely feasible. As a rule, one or more additional experiments are necessary. Specifically, the problem is to define these additional steps in order to gather all the information required at minimum cost and as quickly as possible. It is here that the methodology of process development, and hence of scale up, becomes decisive for the success of operation in producing biodiesel from Jatropha oil. The price of biodiesel is much higher compare to conventional diesel makes it is less chosen by the customer. Thus the aim of this study is to produce biodiesel as diesel substitute with minimum cost with potential to be commercialized.

1.2 Research Objectives

The main objective of this study is to study on different between laboratory scale production and pilot plant production of biodiesel from Jatropha oil. In addition, to establish correlations between laboratory scale and pilot plant scale for construction of commercial plant.

1.3 Scope of Study

I. Study the effect of ratio of alcohol to vegetable oil on biodiesel yield.

II. Study the effect of concentration of catalyst and reaction time on biodiesel yield.

III. Study the effect of reaction temperature on biodiesel yield.

1.4 Significance of Study

Scale up is a very important activity in designing new industrial plants especially in specialty or fine chemicals production. From this study, a pilot plant of biodiesel production can be design based on the parameters and the important variables that used on bench or laboratory scale in order get the maximum biodiesel yield. The optimum conditions can be used in large-scale or pilot plant production to reduce the cost of production.

CHAPTER 2

LITERATURE REVIEW

2.1 Scale Up on Chemical Process

One of the job in which chemical engineer's is involved is the scale-up of laboratory experiment to pilot plant operation or to full-scale production. In the past, a pilot plant would be designed based on laboratory data. However, owing the high cost of a pilot plant-study, this is step is beginning to be surpassed in many instances by designing a full scale plant from the operation of laboratory-bench-scale unit called microplant. To make this jump successfully requires a thorough understanding of the chemical kinetics and transport limitations.

The term ‘scale up’ should not be understood only in the sense of increasing the dimensions while preserving similar systems. Often, the transposition of one system to another offers a better solution to a problem (for example, a pilot plant operating in up flow for an industrial unit operating in down flow).The development of an industrial process is a creative activity, which is aimed at finding and coordinating all the information and data required for the design, construction and start up of a new industrial unit, in order to guarantee an economically profitable operation’ (Trambouze et al., 1975). Figure 2.1 shows the procedure described and identifies the major steps in process development for scale up.

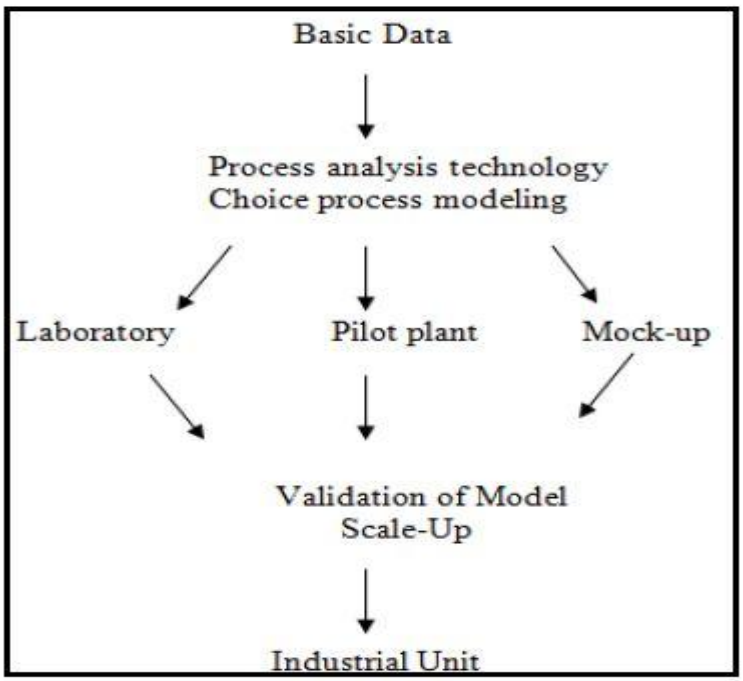

Figure 2.1 The major steps in process development for scale up.

2.1.1 Laboratory Studies

In laboratory-type experiments, in which certain aspects of the process are investigated, by handling relatively small amounts of raw materials in order to reduce the material constraints to the minimum. In the laboratory, a series of measurement can be taken concerning all the mechanisms that are independent of size. This applies in particular to everything related to thermodynamics and chemical kinetics. Moreover, a good number of physical quantities involved in the model, such as densities, specific heats, phase equilibrium, viscosities and more, must be measured through the interval of operating conditions of the process.

2.1.2 Pilot Plant Studies

A pilot plant is an experimental rig, at least part of which displays operations representative of the part corresponding to it in the industrial plant. Representative operation implies operation that is identical or transposable by using a mathematical model of this part of unit.

In pilot-plant experiments, at a scale that varies within wide proportions, but in which all the industrial constraints are taken into account: impurities in raw materials, operation over long periods, materials, equipment reliability, etc. It is during pilot-plant experiments that scale up problems must be dealt with. The pilot-plant experiments alone cannot yield all the answers needed to solve the problem of scale up, and that additional experiments are necessary.

The pilot plant can often be small, because this is not where the scale up data is sought. Hence, its size can be selected both in accordance with certain material constraints and to minimize the total cost of the operation. At this stage, note that the term “scale up” does not correspond exclusively to a change in size of the equipment achieved by multiplying characteristics dimensions by factor greater than one.

The typical activity of process development work remains the pilot plant experiment. This investigation is necessary for one or more of the following reasons:

- The passage from laboratory apparatus to the industrial installation raises scale up problems that are too complex to be solved without an experiment performed with components of intermediate size.

- The operating conditions must be investigated in a representative unit, in which the influence of oil the parameters, such as the type of feed, impurities, recycle, etc., can be taken into account.
- The study of long-term effects, such as catalyst, the activation, buildup of byproducts or impurities, corrosion mechanisms, etc.
- The need to show potential customers an operating pilot plant to convince them of the value of the process and its operational character. This applies especially if the innovative character of the process is a special feature.
- The need to produce representative sample in sufficient quantities for various tests.

A pilot plant must be designed to account for these two requirements, while minimizing its complexity and size, which condition the cost of its construction. However, this work can only be reasonably undertaken if a sufficiently clear idea has first been derived of the future industrial technology. As pointed out, the success of a scale up depends on this first prospective phase.